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Quick-Cooking Dehydrated Vegetable Pieces

I. Properties of Potato and Carrot Products

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SUMMARY

A procedure has been developed to impart a porous structure to vegetable pieces, making them capable of rapid rehydration. The pieces are partially dehydrated in a conventional manner and heated in a closed vessel having a quick-opening lid. When the water contained within the pieces is heated above its atmospheric boiling point and pressure has thereby been developed within the chamber, the pieces are instantly discharged. The flashing of water vapor from within each piece creates a porous structure that permits much faster dehydration and much more rapid rehydration of the dried product.

Carrot and potato cubes of 3/8 inch size made by this method rehydrate in 5–6 min by simmering in water.

INTRODUCTION

Food consumption patterns in the past ten years have shown increasing emphasis on processed rather than fresh vegetables. More products are now packaged as "convenience," "ready-to-eat," and "instant." An even greater emphasis on quickly prepared foods is evident in modern military feeding, where unrefrigerated and rapidly rehydrating products are of primary importance.

Many of the dehydrated vegetables on the market today are slow to rehydrate. This is especially true of two important commodities—potatoes and carrots (3/8-in. dice), respectively requiring about 20 and 30 min of boiling to rehydrate and become soft enough for eating.

The preliminary work on potatoes and carrots reported here was undertaken to develop an economical process for producing dehydrated vegetable pieces that can be rehydrated more rapidly. Commercially dried pieces, other than freeze-dried, possess a dense, horny structure, with most interior capillaries collapsed or greatly shrunken. The work was directed toward creating a porous internal structure suitable for rapid penetration of water on rehydration and, conversely, rapid removal of water on dehydration. Rather than pursue the relatively more expensive methods of freeze-drying or vacuum-puffing, the gun-puffing method familiar to those in the cereal industry was tried (Matz, 1959).

Cereal grains, however, have a lower moisture content than vegetables, which are usually 80% moisture or more. Initial experiments on potatoes showed that puffing at these high moisture contents was not practical, and that a definite range of moisture contents and corresponding puffing pressures should be determined. It was found that fairly well defined limits existed in which a porous structure could be created without disintegration of the piece.

Therefore, the "instantizing" process, as applied to vegetable pieces, consists of partially dehydrating the pieces by conventional means, heating them in a closed vessel having a quick-opening lid until the water contained within the pieces is superheated with respect to steam at atmospheric pressure, then instantly discharging the still intact pieces to atmospheric pressure. The flashing of water vapor from within the pieces creates a porous structure, permitting more rapid final dehydration and more rapid rehydration. The porous structure remains intact during the final dehydration step to a moisture content conducive to good storage stability.

EXPERIMENTAL METHODS

Raw-material preparation. *Potatoes.* Studies were made on potatoes ranging from high solids content (22%) to low solids content (16%). Expressed in terms of cooked potato texture, these solids contents represent a range from dry and mealy to moist and smooth texture. Potatoes were peeled by a 6-min immersion in a 20% solution of NaOH maintained at 150°F. The loosened peels were removed by high-pressure water sprays in a rod-reel-type washer, and remaining defects were removed by hand trimming. To prevent enzymatic darkening before further processing, the potatoes were dipped in a solution containing 0.5% each of sodium bisulfite and citric acid. Sulfited potatoes were diced to appropriate size in an Urschel Laboratories, Inc., Cutter (mention of specific manufacturers or products does not imply endorsement). Dice sizes ranging from 3/8-in. cube, 3/8 × 1/2 × 1/2 in., to 3/4-in. cube were studied, as well as 1/2-in. spheres. (Successful final products were made in all of the above categories; however, the data presented apply only to 3/8 × 1/2 × 1/2-in. dice.)

Pretreatments applied in individual runs on the diced potatoes included: 1) steam blanch, 6 min at 212°F, 2) water blanch, 6 min at 212°F, 3) precooking in water, 5–15 min at 160–165°F (Cording *et al.,* 1955), 4) precooking, as before, followed by a 20-min cooling in water at 45°F (Cording *et al.,* 1959), and 5) precooking and cooling, as before, followed by a 5–15-min steam cooking at 212°F.

Tests were made in which the pretreated pieces were dehydrated to various moisture contents to study the relation between moisture content and puffing pressure on the degree of instantization.

Carrots. Red Core Chantenay was the carrot variety used. Carrots were peeled by immersion 1¾ min in a 20% by weight solution of NaOH at 150°F. Loosened peels were removed in a rod-reel washer with high-pressure water sprays. After a sulfite dip, carrots were cut to dice of 3/8 × 1/2 × 1/2 in. Pretreatment was a steam blanch for 6 min at 212°F, primarily to inactivate enzymes. Carrot dice were partially dried before being puffed.

Partial dehydration. Both potato

and carrot dice were partially dehydrated in either a commercially made through-circulation cabinet-tray dryer, an experimental dryer (Colker, 1946) made at this laboratory, or a belt-trough dryer (Lowe *et al.,* 1955). Potato dice were dried at dry-bulb temperatures of 160–220°F to moisture contents of 24–53%. Carrot dice were dried at 160°F to moisture contents of 37–50%.

Puffing. Both potato and carrot dice were puffed in a commercially made, cereal-type puffing gun (McEwen Manufacturing Co.) (Fig. 1).

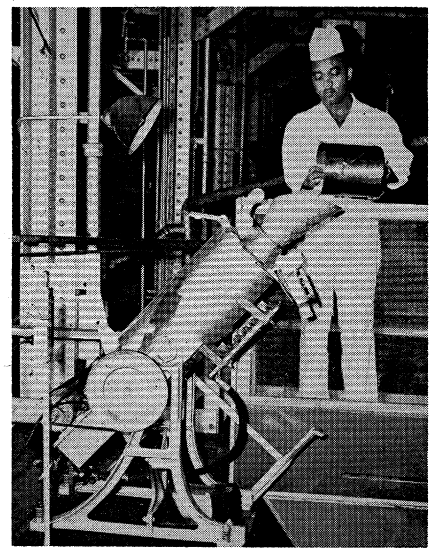

Fig. 1. "Big Husky" puffing gun shown in loading position.

The apparatus consists essentially of a closed chamber provided with a quick-opening lid. Heat to create above-atmospheric pressures in the gun is provided by an external gas flame. Heating of the gun produces steam from the moisture in the charge, and instant release of this pressure to the atmosphere produces a porous structure within the piece. Pressures above atmospheric pressure were 30–60 psig with potato dice and 30–40 psig with carrot dice. Rotational speed of the gun is approximately 40% of the critical speed, i.e., the speed at which the pieces would be held to the interior surface of the gun by centrifugal force. Hence, tumbling action is ensured during the heating cycle.

The time required in heating to the desired puffing pressure is critical, usually 5–8 min. Longer holding periods resulted in a scorched product.

Final dehydration. The instantized pieces were further dehydrated in a through-circulation cabinet-tray dryer at 140–160°F dry-bulb temperatures to a final moisture content of 5–7% for potato dice and 2–4% for carrot dice.

Control samples. Raw potato and carrot dice, pretreated as shown above but not instantized, were dried in a cabinet-tray dryer or a laboratory experimental dryer to moisture contents equal to those of the dehydrated instantized pieces. Dice dried without instantizing are referred to herein as "conventional."

Product evaluation. The rehydration characteristics of the conventional and instantized dice were compared by two criteria: 1) the coefficient of rehydration (Davis and Howard, 1943), which measures the degree of return to the original state; and 2) tenderness as based on LEE-Kramer shear-press readings (Kramer *et al.,* 1951; Kramer, 1957).

The coefficient of rehydration is a percentage figure based on the grams of water absorbed during boiling of the dehydrated piece divided by the grams of water evaporated during processing, each on a common basis of grams of dry solids.

Shear-press readings show the relative force required to cut through a uniform sample of dice. The lower the reading, the more tender the product. For a boiled sample, tenderness is synonymous to "doneness," or degree of cooking.

RESULTS AND DISCUSSION

Results on the effects of the various pretreatments of potato dice are only preliminary. They show that precooking for 15 min at 160°F yielded the most acceptable finished product for high-solids potatoes. The reconstitution characteristics were the same as for the water-blanched sample, but the color of the precooked sample was superior, suggesting a more effective removal of sugars than occurred in the particular blanching treatment used (6 min in boiling water). Results with low-solids potatoes were inconclusive. Further detailed investigations with emphasis on histological studies will be made for better correlation of treatment with end product.

A definite relation was shown between moisture contents of the partially dehydrated potato piece and instantizing (puffing) pressures. Fig. 2 shows this. The correlation coefficient between moisture content and instantizing pressure was determined as 0.61, with a very highly significant relationship between the two factors. At moistures above about 53%, nearly total disintegration of the pieces resulted on instantizing; moistures below about 24% gave a scorched product that rehydrated poorly. Hence, within the moisture range of about 24–53%, optimum puffing pressures vary from about 60 to 30 psi, depending on moisture content. Within these limits of moisture content and puffing pressure, the potato dice prepared had excellent rehydration characteristics. Optimum puffing conditions have not been established to the same degree for carrot dice as for potatoes; also, these conditions do not appear to be as critical. Instantizing carrots at 50% moisture at a release pressure of 30 psig has yielded an excellent product.

Fig. 3 emphasizes the marked difference in dehydration time between conventionally dehydrated pieces and instantized pieces. Pieces were dried conventionally to 44% moisture. After puffing (which reduced moisture content to 40%) the drying curve for the instantized pieces is shown by a broken line. Drying of unpuffed pieces is shown by a solid line. It is apparent that drying time is shortened, saving processing costs and reducing exposure to the oxidative effect of prolonged drying.

Fig. 4 compares the water uptake of instantized potato dice and conventionally prepared dice as measured by the coefficient of rehydration for specified boiling times. The curves show that the instantized dice rehydrate faster than conventional dice. Shear-press data are presented in Fig. 5.

Fig. 6 is a photograph of untreated potato dice (a), conventionally dehydrated dice (b), and instantized dice (c), all boiled for 6 min. It can be seen that the instantized sample closely resembles the untreated sample in return to original piece shape, whereas the conventional sample is shriveled in appearance.

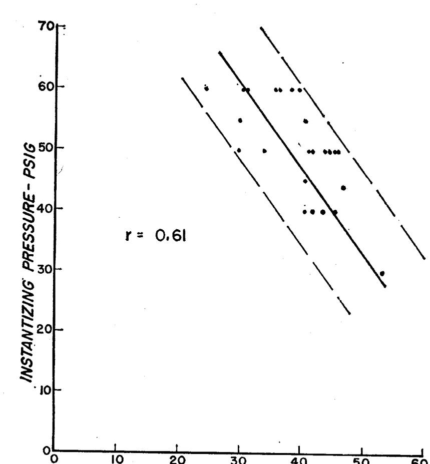

Fig. 2. Optimum puffing conditions for potato dice, showing relation between instantizing pressure and moisture content of charge.

Fig. 7 further emphasizes the difference in appearance between instantized and conventionally dried $\frac{3}{8} \times \frac{1}{2} \times \frac{1}{2}$-in. potato dice boiled 6 min. A cross section of the two dice is shown, stained with Safranin O to illustrate the difference in water pickup. The lighter areas indicate where the water-soluble dye has not yet penetrated, i.e., the entire center section of the conventional piece. Even after continued boiling, the conventional die does not resume its original piece shape to the same degree as the instantized dice.

Results were similar with carrot dice. Fig. 8 shows the more rapid rehydration characteristics of instantized dice by the greater coefficient of rehydration in a shorter boil time than the conventionally dried dice. Fig. 9 presents shear-press data on instantized and conventionally dried $\frac{3}{8} \times \frac{1}{2} \times \frac{1}{2}$-in. carrot dice.

Fig. 10 compares untreated carrot dice (a), conventionally dried dice (b), and instantized dice (c), all boiled for 6 min. The conventional sample presents a shriveled appearance, whereas the instantized sample closely re-

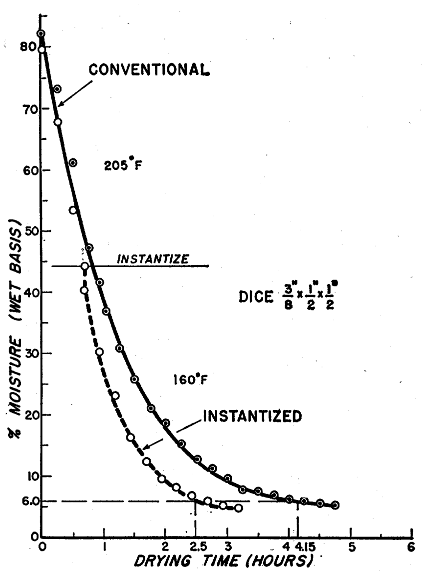

Fig. 3. Comparative drying times of conventional and instantized potato dice. Instantized dice puffed at 44% moisture.

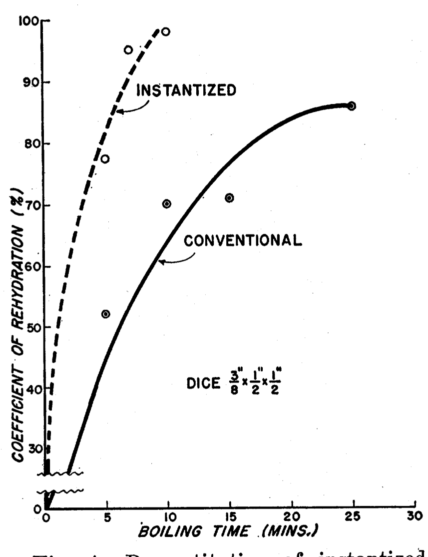

Fig. 4. Reconstitution of instantized and conventional potato dice in boiling water.

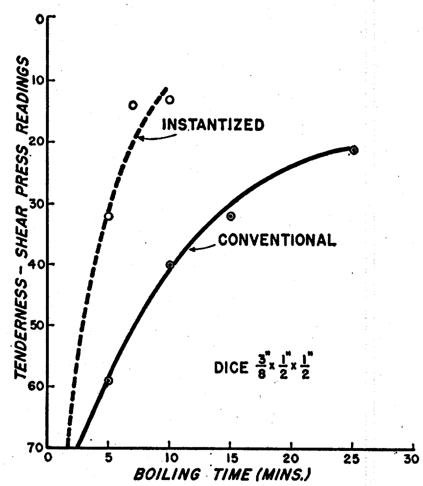

Fig. 5. Relative tenderness of instantized and conventional potato dice during boiling-water reconstitution.

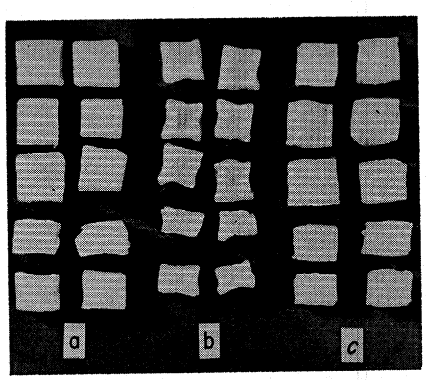

Fig. 6. Comparison of potato dice boiled for 6 min: a) raw, b) conventional, c) instantized.

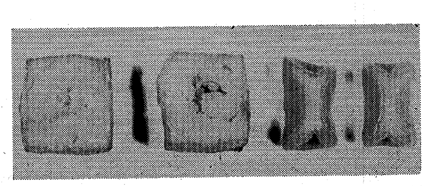

Fig. 7. Cross section of conventional and instantized potato dice after 6-min boil showing relative return to original piece shape and penetration of water-soluble dye.

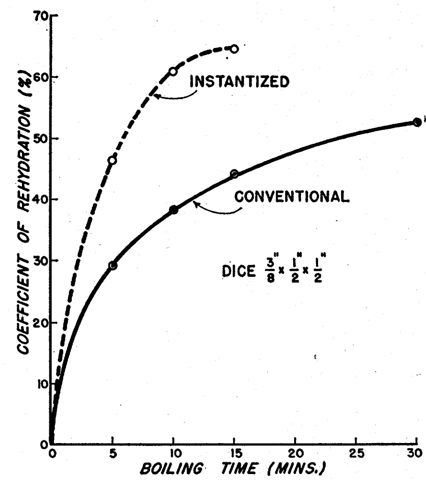

Fig. 8. Reconstitution of instantized and conventional carrot dice in boiling water.

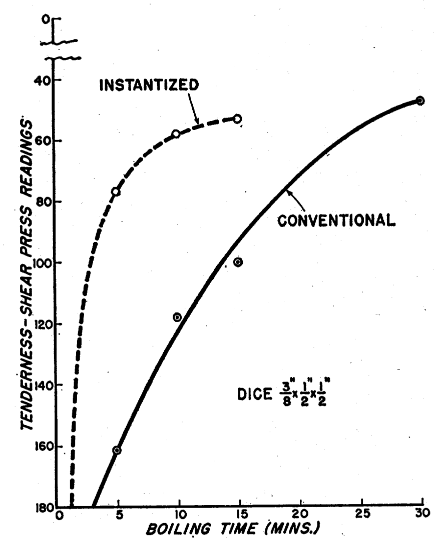

Fig. 9. Relative tenderness of instantized and conventional carrot dice during boiling-water reconstitution.

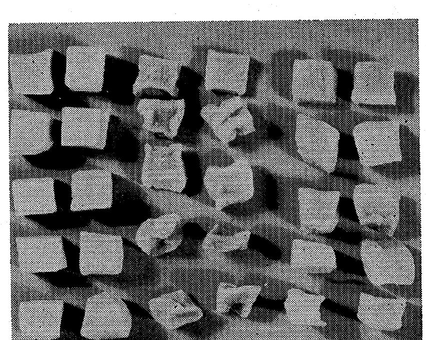

Fig. 10. Comparison of carrot dice boiled 6 min: a) raw, b) conventional, c) instantized.

sembles the untreated sample in return to original piece shape.

Informal taste-panel tests showed that no scorched or burned flavors had been imparted to the potato or carrot dice by virtue of the instantizing process.

The data presented show that considerable improvement can be made in the rehydration characteristics of potato and carrot dice by the application of the instantizing process. Experimental work is continuing in order to establish the optimum pretreatment for starch-containing vegetables, such as potatoes, that will yield the best end product. Extrapolation of the work on potatoes and carrots to other vegetables is contemplated.

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